

Time and Thermodynamics

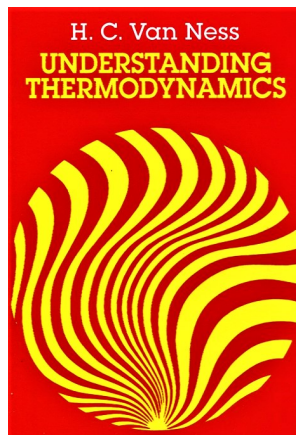
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ABSTRACT

Thermodynamics is the study of energy. Energy can be related to time by various means including assigning an 'arrow to time' from one state of an observable system to another state of the same system after undergoing a thermodynamic change. The **thermodynamic arrow to time** can also be assigned to point from a state or *configuration of higher order* to a state of *lower order* as the entropy of the system increases. In this way time has been defined as a result of **change**.

If the system is in a state of equilibrium then there is no change. Using an evolving thermodynamic system to define time is possible for a changes of state, but this is connected to the use of a standard clock and the observer's T-Computer in the brain. The process of creating time from change does not rely on a dimension of time as in models using space-time. The thermodynamic arrow of time is a construction and not a fundamental property of the universe. Change is a fundamental property of the universe, time is not. Time is a **tool to map** change in the configurations of the universe. **A correct theory of time is needed to understand how arrows of time are constructed.**



Understanding thermodynamics requires **time** to map change.

The first law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic processes, distinguishing two kinds of transfer of energy, as heat and as thermodynamic work, and relating them to a function of a body's state, called internal energy. The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but can be neither created nor destroyed.

The second law of thermodynamics establishes the concept of entropy as a physical property of a thermodynamic system. Entropy predicts the direction of spontaneous processes, and determines whether they are irreversible or impossible, despite obeying the requirement of conservation of energy, which is established in the first law of thermodynamics.

How is time connected with thermodynamics? Let us first review what this author has proposed as the fundamental nature of time.

The 7 principles found to be the **actual nature of time**.

1. **Philosophy of Time**: time exists as information, NOT as a dimension. Time is as real as information is real.
2. **Arrows of Time**: all arrows of time only exist as constructions from signal/information flow in causal networks. All arrows of time point from cause [source] to effect [sink] from simple 2-level systems at the quantum scale such as photon emission in atoms up through the cosmological domain through hierarchical scaling of interconnected causal networks at various plateaus of complexity [POCs]. Arrows of time use **standard clocks** as a reference. **This applies to thermodynamic arrows of time as well.**
3. **Direction of Time**: only exists as directions associated with vectors representing arrows of time pointing from cause to effect [source to sink] in the causal networks of the evolving universe. Various links between nodes in a causal network define a **process** of change that can generate signals carrying information and energy. These process pathways may be **reversible or irreversible**. **Processes do not occur 'in time'** but can generate information used to create a direction for an arrow of time associated with the progress of change in the configurations of systems mapped to standard clocks and processed by our brains T-computer.

NOTE THAT PROCESS REVERSAL IS NOT TIME REVERSAL!

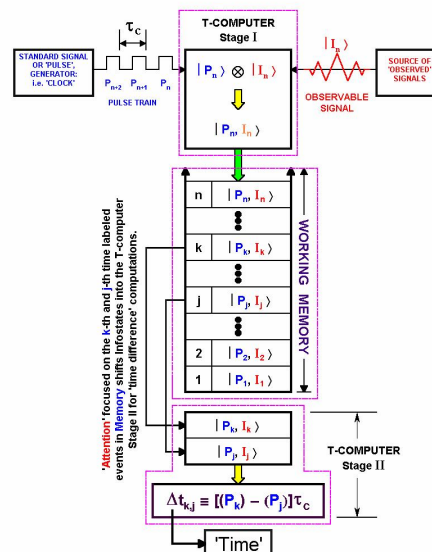
4. **There is no Time to travel 'in', only space** [i.e. the vacuum] where the 'now' created by our consciousness is all we can directly experience. Note that the vacuum exists as a physical entity and space is only a map of this fundamental basis for the universe.

"The Map is not the territory" - Alfred Korzybski

5. **Our brains T-computer** creates 'time' labeled maps of change seen in the observed patterns in the configurations of matter in the universe. The T-computer creates sequential time stamped and labeled memories representing what we perceive. **This is the 'time' we read off any clock.** This has been confirmed by recent fMRI research see **"The evolution of brain activation during temporal processing"**.

Change is a Fundamental property of the universe, time is not.

"No change, then, no time" - J. B. Priestley



See **The T-computer of the Brain** for more about this.

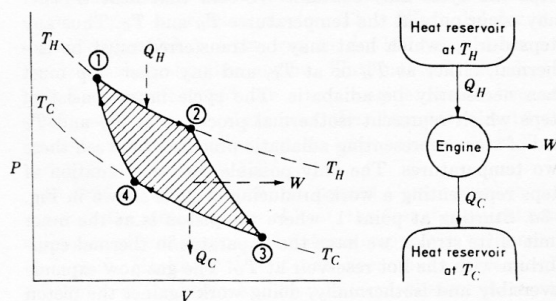
6. **The Problem of Time** therefore has been solved using Feynman Clocks, T-computers, and Causal Networks.
7. **The Vacuum is space and Time is a measure of change** in the configurations of matter floating on the surface of the vacuum. We attribute dimensions to the vacuum [space] as part of our application of geometry

[models] to the real world. The vacuum is much more complex than mere 'empty' space. The vacuum is in fact a multi-vacuum with properties that depend locally on matter and globally on cosmic universality. Cosmological evolution is measured by the maps of change we construct using time as a metric.

Special Note: Time is still useful as a measure of change in our daily lives. Using repeating reproducible regular signal generating systems such as standard clocks [e.g. atomic clocks, watches, computer clocks etc.] gives us a way to create our ordered time maps. Time produced by comparison of a standard clock with the observed system and processed by our brains T-computer or similar 'clocked' information processing devices is 'real'. The reality of time as a pacer of human activities is embedded in our lives. Our manufactured time is used to identify the past of our lives and define the possibilities of the future... **change does not occur *in time* but is used to create information carrying signals that we use to create time labeled memories of the world around us using our internal T-computer in conjunction with external standard 'clocks'.**

Time is not a *parameter*. Time is not observable in a fundamental sense. Time is also not an observable in the quantum mechanical sense. Time is therefore just a number [information] you read from a standard clock and then process with your brains T-computer into time labeled information states [infostates] most likely as memories of the observed events either in your brain or with your instruments.

In the figure below the process from state 1 to state 4 and back to 1 can be used to construct a set of thermodynamic arrows of time pointing from state to state.



A THERMODYNAMIC ARROW OF TIME DEFINED FOR A PROCESS THAT INVOLVES ENERGY FLOW [Q] AND WORK [W]

THE THERMODYNAMIC ARROW OF TIME POINTING FROM THE INITIAL [1] TO THE FINAL [2] STATES OF THE SYSTEM

T	P	V	Q_{rev}	W_{rev}
T_1	P_1	V_1	0	0
T_2	P_2	V_2	Q'_{rev}	W'_{rev}

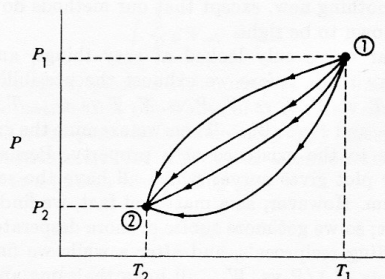
INITIAL STATE USED TO DEFINE INITIAL TIME



* The superscript f to Q_{rev} and W_{rev} indicates a final value.

FINAL STATE USED TO DEFINE FINAL TIME

$t(2)$



THE PATHS FROM STATE (1) TO STATE (2) CAN BE USED TO DEFINE PROCESS DEPENDENT THERMODYNAMIC ARROWS OF TIME 'ALONG' THESE PATHS WHEN COMPARED TO A STANDARD CLOCK

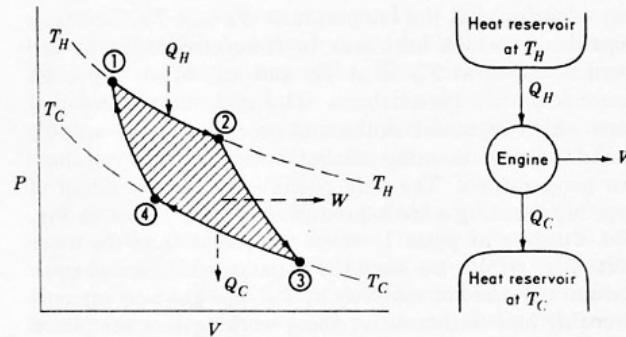
In the figure above we see that a thermodynamic arrow of time can be assigned to the process from state 1 to state 2.

CONCLUSIONS

Because time does not exist as a dimension, space-time maps using all the various arrows of time [e.g. cosmological, quantum, psychological, geological, and classical etc.] that we construct such as the thermodynamic arrow of time discussed here are invalid as direct representations of observable thermodynamic systems in which time is assumed as a fundamental dimension like space [actually the 'vacuum']. The various arrows of time are still instructive at a level of general descriptions of the systems that constitute the evolving universe. The key here is that these various arrows of time are constructions and not more than tools we use to map the evolution of complex systems around us.

In the figure below the process from state 1 to state 4 and back to 1 can be used to construct a set of thermodynamic arrows of time pointing from state to state.

THE PROCESS ILLUSTRATED AT THE RIGHT COULD BE REVERSED BY DOING WORK ON THE SYSTEM OR EXTRACTING WORK FROM THE SYSTEM



THERMODYNAMIC 'ARROWS OF TIME' CAN BE APPLIED TO THE PROCESS PATHWAYS POINTING FROM INITIAL TO FINAL STATES ALONG THE SYSTEM DIAGRAM AT LEFT

NOTE THAT APPLIED ARROWS OF TIME BY AN OBSERVER ARE SCALED USING AN EXTERNAL CLOCK TO QUANTIFY THE TIME SCALE

A THERMODYNAMIC ARROW OF TIME DEFINED FOR A PROCESS THAT INVOLVES ENERGY FLOW [Q] AND WORK [W]

THE THERMODYNAMIC ARROW OF TIME POINTING FROM THE initial [1] TO THE final [2] STATES OF THE SYSTEM

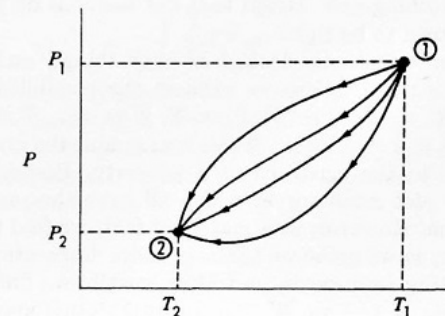
T	P	V	Q_{rev}	W_{rev}
T_1	P_1	V_1	0	0
T_2	P_2	V_2	Q'_{rev}	W'_{rev}

INITIAL STATE USED TO DEFINE INITIAL TIME



FINAL STATE USED TO DEFINE FINAL TIME

$t(2)$



THE PATHS FROM STATE (1) TO STATE (2) CAN BE USED TO DEFINE PROCESS DEPENDENT THERMODYNAMIC ARROWS OF TIME 'ALONG' THESE PATHS WHEN COMPARED TO A STANDARD CLOCK

ALL THE THERMODYNAMIC LAWS ARE NOT VIOLATED DURING THE FORWARD PROCESS OR ITS PROCESS REVERSAL

In the figure above we see that a thermodynamic arrow of time can be assigned to the process from state 1 to state 2.

PROCESS REVERSAL IS NOT TIME REVERSAL !!!